# 7. Transmission and Distribution

## Highlights

- *Ameren Missouri will construct nineteen of twenty-six transmission projects that have been approved by the Midcontinent Independent System Operator (MISO) Board of Directors in Missouri for completion before 2026.*
- *Ameren Missouri has developed the Smart Energy Plan (SEP), a comprehensive, forward-looking plan designed to upgrade the electric grid and bring significant benefits to customers.*
- *The plan includes $9.9 billion of electric investments from 2023 through 2027 that will, among other things, accelerate our investment in smart grid technologies, system hardening efforts, and upgrading infrastructure.*

Ameren Missouri is continuously maintaining or replacing aging infrastructure in order to meet its obligation to provide safe and adequate service and to endeavor to meet its customers' reliability expectations. Rapid growth during the 1960s and 1970s, spurred by a housing boom and the advent of air conditioning, resulted in a replacement of the previous vintage infrastructure and an even larger, new system. As growth has slowed over time, the infrastructure has not experienced optimal turnover. This lack of asset turnover means our existing grid is heavily populated with 40 to 60-year-old equipment that is at risk of failure, obsolescence, and inefficiencies as compared to modern equipment. While the company has always worked to improve its electric grid, SEP has allowed Ameren Missouri to markedly increase its efforts in this area with its plans to make investments to replace its aging grid infrastructure so that it can continue to provide customers safe and adequate service. On the transmission side, a total of 26 transmission projects have been approved by the MISO Board of Directors for construction in Missouri for completion before 2026. Ameren Missouri will construct 19 of these projects. The projects will mitigate future reliability issues and provide for continued safe and reliable service to customers.



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# 7.1 Transmission

## 7.1.1 Existing System[1]

Ameren Missouri owns and operates a 2,970-mile transmission system that operates at voltages from 345 kV to 138 kV. The system is composed of the following equipment:

- 1,313 miles of 138 kV transmission circuits.
- 835 miles of 161 kV transmission circuits.
- 978 miles of 345 kV transmission circuits.
- Substations that make up the Bulk Electric System:
  - 23 extra high voltage substations with a maximum voltage of 345 kV.
  - 39 substations with a maximum voltage of 161 kV.
  - 34 substations with a maximum voltage of 138 kV.

## 7.1.2 Regional Transmission Organization Planning[2]

Since 2004, Ameren Missouri has been a member of MISO, a Regional Transmission Organization (RTO). MISO was approved as the nation's first RTO in 2001 and is an independent nonprofit organization that supports the delivery of wholesale electricity and operates energy and capacity markets in 15 U.S. states and the Canadian province of Manitoba.

A key responsibility of the MISO is the development of the annual MISO Transmission Expansion Plan (MTEP). Ameren Missouri is an active participant in the MISO MTEP development process. Participation in the MISO MTEP process is the method by which Ameren Missouri's transmission plan is incorporated into the annual MTEP document. The overall planning process can be described as a combination of "Bottom–Up" projects identified in the individual MISO Transmission Owners' transmission plans which address issues more local in nature and are driven by the need to safely and reliably provide service to customers, and projects identified during MISO's "Top-Down" studies, which address issues more regional in nature that provide economic benefits or address public policy mandates or goals.[3] MISO's Long Range Transmission Plan (LRTP), which resulted in approval of approximately $10 billion of new transmission projects,[2] including approximately $1 billion of investments in Missouri is an example of the top-down approach. These projects were approved as a part of the MTEP21 process.

Through these MTEP related activities, Ameren Missouri works with MISO, adjacent RTOs and Transmission Planning Regions, adjacent MISO Transmission Owners and stakeholders to promote a robust and beneficial transmission system throughout the

[1] 20 CSR 4240-22.045(1)
[2] 20 CSR 4240-22.045(3)
[3] 20 CSR 4240-22.045(3)(B)1

Midwest region. Ameren Missouri's participation helps ensure that opportunities for system expansion that would provide benefits to Ameren Missouri customers are thoroughly examined. This combination of Bottom-Up and Top-Down planning helps ensure all issues are addressed in an effective and efficient manner.[4]

Guidance is provided to MISO on the assumptions, inputs, and system models that are used to perform the various analyses of the overall MISO transmission system. Ameren Missouri's participation in the MTEP development process includes: review of MISO and stakeholder developed material, comments and feedback, and working to assure the projects approved in the MTEP are in the interests of the Ameren Missouri customers. Ameren Missouri is regularly represented by attendance and participation in the MISO stakeholder organizations which are key components of the MTEP development process including the:

- Planning Advisory Committee (PAC) – The PAC provides input to the MISO planning staff related to the process, adequacy, integrity and fairness of the MISO wide transmission expansion plan.
- Planning Subcommittee (PSC) – The PSC provides advice, guidance, and recommendations to MISO staff with the goal of enabling MISO to efficiently and timely execute its planning responsibilities, as set forth in the MISO Tariff, MISO/Transmission Owner Agreement, Federal Energy Regulatory Commission (FERC) Orders applicable to planning and other applicable documents.
- Interconnection Process Working Group (IPWG) – The IPWG has the goal of reducing study time and increasing certainty associated with new requests to connect generation to the transmission grid within MISO.
- Sub-regional Planning Meetings (SPM) – The SPMs are hosted by MISO in accordance with FERC Order 890, to encourage an open and transparent planning process. Stakeholders are encouraged to participate in discussions of planning issues and proposals on a more local basis and discuss projects, issues and concepts that are potentially driving the need for new transmission expansions.
- Loss Of Load Expectation Working Group (LOLEWG) – The LOLEWG works with MISO staff to perform Loss of Load Expectation analysis that calculates the congestion free Planning Reserve Margin requirements as defined in Module E of the MISO Tariff.
- Regional Expansion Criteria and Benefits Working Group (RECBWG) – The RECBWG is a forum for stakeholders to provide input in the various processes used in the MISO tariff to allocate the cost of transmission system upgrades and improvements to the appropriate beneficiaries.

[4] 20 CSR 4240-22.045(3)(B)1; 20 CSR 4240-22.045(3)(B)2; 20 CSR 4240-22.045(3)(B)3

- Interregional Meetings – Numerous meetings are held each year with PJM RTO, SPP RTO, and the Southeastern Regional Transmission Planning Region to discuss, evaluate and consider interregional transmission issues and identify opportunities for transmission expansion, consistent with the respective RTO's regional planning processes.
- Other Committees, Task Forces and Working Groups as appropriate.

The result of the MTEP process is a compilation of transmission projects that are needed to address system reliability requirements, improve market efficiency, and/or provide specific system benefits as delineated in the MISO Tariff. The MTEP identifies solutions to meet regional transmission needs and to create value opportunities through the implementation of a comprehensive planning approach.

Each MTEP document is identified by the year in which it was completed. Appendix A of each MTEP lists and briefly describes the transmission projects that have been evaluated, determined to be needed and subsequently approved by the MISO Board of Directors. The MTEP21 document is the culmination of more than 18 months of collaboration between MISO planning staff, MISO Transmission Owners, and stakeholders. Each MTEP cycle focuses upon identifying system issues and improvement opportunities, developing alternatives for consideration, evaluating those options to determine the most effective solutions and finally identifying the preferred solution. As described in more detail in the MISO Tariff, the primary purposes of the MTEP process are to identify transmission projects that:

- Ensure the transmission system supports the customer's needs in a continued safe and reliable manner.
- Provide economic benefits such as increased market efficiency and resultant overall lower energy cost.
- Facilitate public policy objectives such as integrating renewable energy resources.
- Address other issues or goals identified through the stakeholder process.

The interconnection of new generation resources to the transmission system under MISO's control is also an important part of the overall transmission planning effort. Ameren Missouri actively participates in regional generation interconnection studies for proposed generation interconnections inside and outside of the Ameren Missouri area. Participation in these transmission studies ensures that they are performed on a consistent basis and that the proposed connections and any system upgrades needed on the Ameren Missouri transmission system are properly integrated and scheduled to maintain system reliability.

With the approval of MTEP21, a total of 26 transmission projects have been approved by the MISO Board of Directors for construction in Missouri before 2026. A summary of the projects is shown in the table below. Table 7.1 also includes the proportion of transmission service charges arising from the projects that will be assigned to the Ameren Missouri load zone.[5] The costs of these projects are not impacted by whether the project is constructed by Ameren Missouri or an affiliate.

**Table 7.1 MTEP Transmission Projects in Missouri in MTEP21 or Prior – Summary**

| Project Type | Number of Projects | Estimated Total Project Cost ($Million) | Estimated Percentage of Transmission Service Charges Arising from the Projects to be assigned to the Ameren Missouri Load Zone |
|---|---|---|---|
| Baseline Reliability or Reliability/Other Projects Not Cost Shared | 24 | $501 | 100% |
| GIP projects | 2 | $17 | 8% |

A brief description of the 26 transmission projects can be found in Appendix A.[6]

A key component of fulfilling Ameren Missouri's obligation of continuing to provide safe and adequate service is the identification of potential future needed transmission upgrades. A list of projects that are under consideration by Ameren Missouri and MISO and that are located totally or partially in Missouri is provided in Appendix A in Table 7A.2.

Current and previous transmission system expansion plans can be found on MISO's website: https://www.misoenergy.org/planning/planning/.[7]

### *Revenue Credits from Previously Constructed Regional Transmission Upgrades*[8]

Regional transmission upgrades, such as Multi-Value Projects (MVP) and Market Efficiency Projects, are eligible for cost sharing under Attachment GG or MM of the MISO Tariff. Ameren Missouri does not have any Multi-Value or Market Efficiency projects which result in revenue credits. However, Ameren Missouri does have four Baseline Reliability Projects that were approved for regional cost sharing under a prior version of Attachment GG. Ameren Missouri expects approximately $10.6 million of Schedule 26 revenue in planning year 2023-24. It should be noted that over 90% of Ameren Missouri's Attachment GG revenue requirement will be allocated to the AMMO pricing zone and reflected in the rates paid by Ameren Missouri retail and wholesale customers.

[5] 20 CSR 4240-22.045(3)(A)4
[6] 20 CSR 4240-22.045(6)
[7] 20 CSR 4240-22.045(3)(C)
[8] 20 CSR 4240-22.045(3)(A)5

### 7.1.3 Ameren Missouri Transmission Planning[9]

Ameren Missouri's transmission strategy is centered upon meeting the evolving needs of its customers and Ameren Missouri's commitment to provide them safe and adequate service, and to endeavor to meet their increasing reliability expectations. Each year the Ameren Missouri transmission system is thoroughly examined and studied to verify it will continue to provide Missouri customers with reliable and adequate service through compliance with all applicable North American Electric Reliability Corporation (NERC) standards as well as Ameren's Transmission Planning Criteria and Guidelines.

The studies identify potential system conditions where reduced reliability may occur in the future. Additional studies are then performed to evaluate all practical alternatives to determine what, where, and when system upgrades are required to address the future reliability concern. This annual review identifies any transmission system reinforcements necessary to provide reliable and safe service in response to changing system conditions. These studies consider the effects of overall system load growth, the adequacy of the supply to new and existing substations to meet local load, the expected power flows on the bulk electric system and the resulting impacts on the reliability of the Ameren Missouri transmission system.

In order to successfully achieve the goal of a safe and reliable transmission system, Ameren Missouri participates in a multitude of transmission planning activities including:

- MISO Transmission Expansion Plan development
- MISO regional generation interconnection studies
- NERC reliability standards development
- Participation in SERC regional planning and assessment activities

This high level of involvement affords the opportunity to supply comments and provide input to these many transmission planning processes which supports the goal of maintaining a reliable and safe transmission system which will meet the current and future needs of our Missouri customers.

As part of the Ameren Missouri Transmission Planning Process, the ability of transmission system improvements to reduce transmission system losses is considered. A major aspect of Ameren Missouri's focus of providing continued safe and adequate service to our customers and to meet their reliability expectations is maintaining transmission equipment and replacing aging infrastructure when it approaches the end of its operational life. The Ameren Missouri area experienced rapid economic growth and substantial investment in transmission infrastructure during the 1960s and 70s. Considerable portions of the transmission system are now over forty years old and are

[9] 20 CSR 4240-22.045(3)(B)1; 20 CSR 4240-22.045(3)(B)2; 20 CSR 4240-22.045(3)(B)3; 20 CSR 4240-22.045(3)(B)4

reaching the end of their operational life with a commensurate increased risk of failure and higher maintenance expense. The existing equipment is also less efficient than comparable modern equipment. Ameren Missouri is working to address the most critical issues by making targeted investments to replace its aging grid infrastructure to maintain system reliability, consistent with available capital.

### 7.1.4 Transmission Impacts of Potential Ameren Missouri Generation Resource Additions/Retirements & Power Purchases/Sales[10]

As part of the determination of the proper combination of resources needed to serve the Ameren Missouri load, the size and location of potential future generation resources are estimated. This requires an assessment of the transmission system enhancements necessary to deliver energy safely and reliably from these potential future resources.

Table 7.2 provides a high-level assessment of interconnection costs for the listed potential future generation resources. These estimates do not include costs for non-MISO affected systems but do include estimated cost of network upgrades in MISO footprint, which may be impacted by other new resources connecting to the grid, revisions to resource timing, new transmission projects and other factors. Actual projects and costs would be determined via the MISO generation interconnection process at the time these projects are developed.

**Table 7.2 Transmission Project Costs for New Generation**

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As part of the determination of the proper combination of resources needed to serve the Ameren Missouri load, the need for continued operation of existing resources is examined. This requires determining the overall impact of retiring existing generation resources on the transmission system and identifying any system upgrades necessary to maintain safe and adequate service after the resource is no longer available.

[10] 20 CSR 4240-22.040(3); 20 CSR 4240-22.040(3)(A); 20 CSR 4240-22.045(1)(B); 20 CSR 4240-22.045(1)(C); 20 CSR 4240-22.045(3)(D)



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Table 7.3 and Table 7.4 contain the results of a high-level assessment of the cost to Ameren Missouri customers of transmission system upgrades needed to provide continued safe and adequate service when the indicated Ameren Missouri generators retire within the planning period. These estimates may be impacted by new resources connecting to the grid, revision of the shutdown timeframe, new transmission projects and other factors.

**Table 7.3 Estimated Transmission Project Costs for Reactive Support**

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**Table 7.4 Estimated Transmission Project Costs for Thermal Upgrades**

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### *Transmission Impacts due to New Generation Resource Connections within the MISO Footprint or Point-to-Point Transfers of Energy within the MISO Footprint to Ameren Missouri*

Ameren Missouri participates in regional generation interconnection studies for proposed generation interconnections inside the MISO footprint. Participation in these activities ensures that the studies are performed on a consistent basis and that the proposed connections are integrated into the Ameren Missouri system to maintain system reliability. Power flow, short-circuit, and stability analyses are performed to evaluate the system impacts of the requested interconnections. If system deficiencies are identified in the



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connection and system impact studies, additional studies are performed to refine the limitations and develop alternative solutions.

New Generation Resources - Future generation resources within the MISO footprint seeking to connect to the transmission system will be subject to the interconnection requirements described in the MISO Tariff and applicable MISO Business Practice Manuals. In order to interconnect to the transmission system, the resource owner must provide project details including location, resource size, type of service requested, when it wants to connect, etc. After this information has been received, the impacted Transmission Owner and MISO will perform the system study and analysis necessary to determine the transmission upgrades needed to safely and reliably interconnect the generation resource to the transmission system.

Point to Point Transactions - The MISO Tariff and applicable MISO Business Practice Manuals describe the process by which transmission service requests can be made to have firm point-to-point transmission service within the MISO footprint. The entity requesting service would provide details including: source and delivery locations, quantity of energy to be transmitted, timing and duration of delivery, etc. After this information has been received, the impacted Transmission Owner(s) and MISO will perform the system study and analysis necessary to determine the transmission upgrades needed to safely and reliably support the requested transmission service. The transmission upgrades needed to support a transmission service request will not be determined until the completion of the system study and analysis. The MISO Tariff and MISO Business Practice Manuals that are in effect at the time when the point-to-point transmission service request is submitted will describe the process by which Financial Transmission Rights (FTRs) are allocated and can be obtained by entities.

The total cost of any necessary transmission upgrades cannot be determined until a resource interconnection request and/or a transmission service request has been submitted to MISO via the process described in the MISO Tariff and applicable Business Practice Manuals and the necessary transmission system studies have been performed. The result of the studies will identify the transmission system upgrades necessary to safely and reliably fulfill the transmission service request or generation interconnection request. The studies will include a description of the needed transmission system reinforcements, their location, in service date and estimated total cost. Therefore, the cost of any needed system upgrades will not be known until the system study and analysis is complete.

***Transmission Impacts due to New Generation Resources outside the MISO Footprint affecting the MISO Transmission System or Point-to-Point Transfers of Energy from Outside the MISO Footprint to Ameren Missouri***

Ameren Missouri participates in generation interconnection studies for proposed generation interconnections for generators located outside of the MISO footprint. Participation in these activities ensures that the studies are performed on a consistent basis and that the impact of the proposed connections do not adversely affect the Ameren Missouri system reliability. Power flow, short-circuit, and stability analyses are performed to evaluate the system impacts of the requested interconnections. If system deficiencies are identified in the connection and system impact studies, additional studies are performed to refine the limitations and develop alternative solutions.

Point to Point Transactions - The MISO Tariff and applicable MISO Business Practice Manuals describe the process by which transmission service requests can be made to have firm point-to-point transmission service into the MISO footprint from a generation resource located outside the MISO footprint. The entity requesting service would provide details, including: source and delivery locations, quantity of energy to be transmitted, timing and duration of delivery, etc. After this information has been received, the impacted TO(s) and MISO will perform the system study and analysis necessary to determine the transmission upgrades needed to safely and reliably support the requested transmission service. The transmission upgrades needed to support a transmission service request will not be determined until the completion of the system study and analysis. The MISO Tariff and MISO Business Practice Manuals that are in effect at the time when the point-to-point transmission service request is submitted will describe the process by which FTRs are allocated and can be obtained by entities.

The total cost of any necessary transmission upgrades cannot be determined until a transmission service request has been submitted to MISO via the process described in the MISO Tariff and applicable Business Practice Manuals and the necessary transmission system studies have been performed. The results of the studies will identify the transmission system upgrades necessary to safely and reliably fulfill the transmission service request. The studies will include a description of the needed transmission system reinforcements, their location, in service date and estimated total cost. Therefore, the cost of any needed system upgrades will not be known until the system study and analysis is complete.

### 7.1.5 Cost Allocation Assumptions for Modeling[11]

The MISO Tariff allocates 100% of the Baseline Reliability Projects revenue requirements to the local zone where the project is located. The MVP revenue requirements are

[11] 20 CSR 4240-22.045(3)(A)4

collected under MISO Tariff Schedule 26-A, which is charged to Monthly Net Actual Energy Withdrawals, Export Schedules, and Through Schedules. MISO estimated charges include the MVPs approved in December 2011 and the LRTP projects approved in 2022 as part of MTEP21 by the MISO Board of Directors. Overall, Ameren Missouri expects approximately 7.3% of the MVP costs to be assigned to its load zone.

### 7.1.6 Advanced Transmission System Technologies[12]

The Company will continue to evaluate the latest technologies when developing long-range plans to maintain and strengthen the reliability, resiliency, and flexibility of the transmission system. With customer focus in mind, we will position ourselves to act if innovative technologies present opportunities to solve anticipated grid deficiencies at a higher value than traditional methods. Federal, state and RTO policies continue to develop to address operational and market issues related to emerging technologies. Ameren Missouri will monitor and work to shape these policies when applicable to result in the most favorable outcomes for our stakeholders. Increasing customer adoption of advanced technology, including distributed energy resources (DERs), will impact energy demand and usage of the transmission system as the load becomes more dynamic. In line with Ameren's 2030 Vision, the transmission system of the future will be a vital component of a more integrated, bi-directional, and smarter electrical grid. Ameren Missouri will need to plan the system to transform from one designed to deliver central station generation to customer load into a modern system that will accommodate more variable and geographically dispersed generating facilities connected at both transmission and distribution voltage levels. Flexibility will be key to maintaining reliable service in the face of various uncertain future scenarios. Emerging technologies and their declining costs are also likely to introduce new areas in which Ameren Missouri will need to compete to retain and win customers by ensuring our service is reliable and affordable. To ensure customer value in the future, the entire electrical grid will be better utilized as a vehicle to offer individualized service to customers and market participants including the ability to buy and sell energy with the energy company and others.

Innovation and modern technology are the catalyst for creating customer value and enhancing efficiency that will keep our product affordable in the future. Just as the transition to renewables will influence expansion of the transmission grid, so too will new technologies and the need to integrate grid connected devices to the energy networks.

Invertor based resources (IBR) are starting to connect to the Ameren Missouri transmission system in larger numbers to replace the power lost by retiring synchronous generation. IBRs consist of anything that converts direct current to alternating current,

[12] 20 CSR 4240-22.045(3)(A)2; 20 CSR 4240-22.045(3)(A)4; 20 CSR 4240-22.045(3)(B); 20 CSR 4240-22.045(1)(D); 20 CSR 4240-22.045(4)(A); 20 CSR 4240-22.045(4)(C); 20 CSR 4240-22.045(4)(D); 20 CSR 4240-22.045(4)(E)1; 20 CSR 4240-22.070(1)(B)

including photovoltaic, new wind turbines, and battery energy storage systems. The location of the IBRs results in the loss of the load voltage regulation that used to be performed by the retiring local synchronous generation. Along with the softer voltages, the system as a whole will be weaker, which results in falling fault current, which leads to a larger voltage bump when closing static reactive devices onto the system and difficulty for transmission-based distance relays to determine direction.

If needed, the required voltage regulation can be replaced by adding reactive resources close to where the generation was retired. Ameren Missouri put its first STATCOM into service at Meramec substation in 2022 for that reason. The Meramec STATCOM not only provides voltage regulation and dynamic fault recovery voltage boosting, but also provides two new technologies for improved system performance. The STATCOM was also specified with independent phase control, which was adapted on Ameren's request to produce negative phase sequence current during a fault to polarize transmission relays so they can correctly determine the direction of a fault. In early 2024, Ameren Missouri will be installing its first variable reactor, which allows for larger overall sized reactors, which help control the system voltage in light load conditions. These reactors can move with the system, giving dynamic voltage control, but do not significantly bump the system on closure.

Recently, Ameren Missouri has updated its transmission-level substation design to continually monitor all elements of the substation to remove single points of failure, including new items such as battery monitors. By using fiber and IEC61850, which is ethernet technology, to connect relays and the remote terminal units, control switches and lockouts have been eliminated, wiring and the number of panels has been reduced, along with reducing the size of the control building.

Ameren Missouri has started scanning its transmission-level substations, which allows for virtual field visits and increased accuracy in scoping. The scanning allows for viewing nameplates and taking measurements while increasing safety, by reducing the need to visit the substation. The use of both 3D technology and smart wiring has made designs more accurate and the has increased the efficiency and accuracy of field prints.

Building on the advancement in unmanned aerial vehicles, or drones, artificial intelligence (AI) is now being used to analyze the three hundred thousand photographs taken each year, at a rate of 1,500 photos an hour. Presently the AI has been taught to detect woodpecker damage, and is currently learning to detect broken crossarms, insulator damage, birds' nests and objects that have been built within the right of way of the transmission line.

The work on the network model manager continues to synergize all the engineering planning modeling process, to avoid manual activity and to eliminate modeling errors. As the load becomes more dynamic, and the generation more intermittent, the requirement of accurate input data and the need to run a multitude of scenarios to cover possible future scenarios demands an adaptive integrated planning model that optimizes solutions that are reliable, affordable and resilient.

Technological advances and declining costs on the customer side are expected to continue. This will introduce the possibility of the need to compete for customers that may have cost competitive alternatives to grid-connected energy. Grid connected customer adoption of DERs and energy efficiency driven by product technology will affect the usage of the transmission system. Planning will continue to be needed for a variety of uncertain future scenarios to ensure a reliable transmission system.

### 7.1.7 Ameren Missouri Affiliates Relationship[13]

Ameren Missouri's focus is upon continuing to provide safe and adequate service to its customers. Ameren Missouri has prioritized its capital investments to address local issues, including: improving its aging distribution and transmission infrastructure and energy centers, accomplishing mandated environmental investments, implementing mandated transmission upgrades (e.g., for NERC compliance), and complying with other state and federal mandates (such as the Missouri Renewable Energy Standard (RES)). These kinds of investments must be made to deliver safe and adequate service to Ameren Missouri’s customers.

An Ameren Missouri affiliate, Ameren Transmission Company of Illinois (ATXI), invests capital in transmission infrastructure that provides a variety of benefits to transmission customers both inside and outside of the MISO Ameren Missouri pricing zone. For example, the recently constructed MISO MVPs consisted of a portfolio of large transmission projects providing reliability, economic, and public policy benefits to customers throughout the Midwest. Alternatively, ATXI also invests in smaller, more localized projects that benefit multiple parties within the MISO Ameren Missouri pricing zone. ATXI is currently constructing a new substation near Rolla, Missouri, that will more efficiently utilize existing high voltage lines, which will provide reliability enhancements to Ameren Missouri retail customers as well as Rolla Municipal Utilities. Ameren Missouri does not plan to construct these kinds of projects because it is in the best interests of its Missouri customers that it invest its limited capital only in generation, distribution and transmission investments needed to provide safe and adequate service to its load, including the transmission improvements needed to connect an Ameren Missouri generating unit to the grid. Because of its limited capital, Ameren Missouri has concluded that it should not invest in other transmission projects, such as MVPs, because investing in regional transmission would undermine Ameren Missouri’s ability to deliver safe and

[13] 20 CSR 4240-22.045(3)(B)5; 20 CSR 4240-22.045(5)

adequate service. The building of these projects by ATXI will not impact the cost of the project relative to construction by Ameren Missouri.

### 7.1.8 Avoided Transmission and Distribution Cost[14]

Avoided transmission and distribution costs are based upon integrated system effects and are difficult to quantify, as opposed to energy and capacity costs where there are markets that provide specific prices. As part of integration modeling, Ameren Missouri estimated the MW impacts of demand side management (DSM) programs and a corresponding reduction in transmission and distribution capital expenditures.

Ameren Missouri has previously calculated the marginal cost of system capacity in lieu of avoided transmission/distribution costs; however, this approach presents complications due to the fact that projects serve a variety of purposes - capacity upgrades to serve incremental system load, capacity upgrades to serve relocated system load, and refurbishment or replacement of equipment to avoid imminent failure. Therefore, Ameren Missouri decided to follow the 'Current Values Approach,' which is a more straightforward approach and is used by other utilities.[15] The Current Values Approach estimates an average cost of serving the load by taking the net transmission/distribution plant in service and dividing it by the weather-normalized peak load. Ameren Missouri further applied the condition/reliability factor as it has done in its previous IRPs to the average cost of serving the load estimated using the Current Values approach, as not all expenditures can be deferred by the DSM programs. The resulting avoided transmission and distribution costs can be found in Appendix A, Table 7A.3.

## 7.2 Distribution

### 7.2.1 Existing System[16]

Ameren Missouri delivers electricity to approximately 1.2 million customers across its service territory in Missouri, including the greater St. Louis area, through the primary distribution system power lines that operate at voltage levels ranging from 2,400 volts (V) through 69,000 V. Ameren Missouri has over 33,000 circuit miles of electric distribution lines, which supply electricity to 63 counties and more than 500 communities where businesses operate, and people live.

Approximately 70% of Ameren Missouri's distribution system operates at 12,470 V, 12% operates at 4,160 V, and 11% operates at 34,500 V. The remaining 7% operates at other nominal voltage levels. (See Figure 7.1 for further information.)

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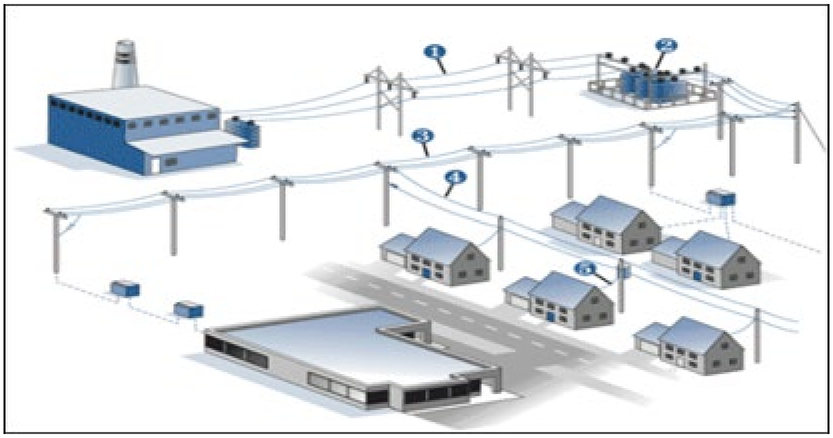
[14] 20 CSR 4240-22.045(2); 20 CSR 4240-22.045(3)(A)3

[15] https://mendotagroup.com/wp-content/uploads/2018/01/PSCo-Benchmarking-Avoided-TD-Costs.pdf

[16] 20 CSR 4240-22.045(1)

**Figure 7.1 Power Flow**



**Here is how electricity flows from a power plant to an electric customer:**

1. Electricity travels from the power plant over high-voltage transmission lines.
2. At a substation, the electricity's voltage is lowered so that it can travel over the distribution system.
3. Main distribution power lines bring electricity into communities.
4. Local distribution power lines serve neighborhoods and individual customers.
5. Service drops carry electricity from pole-mounted or pad-mounted transformers, which lower the voltage again, to customer premises.

Much of the distribution system in rural areas is supplied via single substations operating in radial configurations. Long distribution feeders are usually required to serve multiple isolated rural communities. Long feeders are usually equipped with automatic reclosers to interrupt fault currents and isolate damaged sections, thereby restoring service to upstream portions of the feeder and its respective customers. Where possible, normally open tie switches are installed in downstream sections of feeders to provide emergency service from another source during upstream planned or unplanned outages. The company installs capacitors and/or voltage regulators, as necessary, to counteract voltage drops and maintain proper voltage levels along lengthy circuits.

A more interconnected distribution system is justified to serve densely populated urban areas. Although substations operate in radial configurations, two or more supply circuits are normally available on the primary side of substation transformers. Each customer is served by a single power source at any given time, but the company can re-configure the interconnected system to maintain service to customers via alternate sources when portions of the system must be de-energized to perform maintenance or complete repairs. Although voltage levels tend to be less of an issue in closely coupled, interconnected systems, the company does employ capacitors to maintain power factor within prescribed limits.

Finally, a portion of the distribution system is networked, meaning customers are continuously connected to more than one power source. Examples include the 208Y/120 V underground distribution network in downtown St. Louis and the 69 kV network that supplies communities throughout central Missouri, including Jefferson City, Kirksville, Moberly, and Montgomery City. Networked systems offer the advantage of supplying customers from more than one power source so that they are less susceptible to a sustained total loss of power. However, since the system is networked, disturbances in the distribution system tend to affect a larger number of customers. Automatic isolation of faulted equipment and control of power flow in networked systems are more difficult than in radial systems. For these and other reasons, the Company employs networked systems on a limited basis in Missouri.

Ameren Missouri's distribution system includes both overhead and underground power lines. Underground lines (24% of the total distribution line miles) are more aesthetically pleasing and are significantly less vulnerable to weather-caused damage but can take longer to repair upon failure.

### 7.2.2 The Aging Grid

As previously stated, much of Ameren Missouri's existing electrical grid was expanded during the 1960s and 1970s. This was a period of increased electricity use driven by significant suburbanization, increased use of air conditioners, and industrial growth. Today, decades later, much of this infrastructure is rapidly approaching obsolescence, with the associated increased risk of failure and inefficiencies as compared to modern equipment.

One area where we can especially see the impact of an aging system is in the challenges we face in operating effectively in the face of extreme weather while under peak demand conditions. As recent winter storms have shown us, there are areas of the grid where a lack of capacity to meet growing peak loads, combined with little operating flexibility, could leave limited ability to switch and restore customers in the event of downed power lines, much less during extreme weather. This has resulted in what we consider excessive customer outages, for prolonged periods.

Another example is distribution substations. When SEP investments began in 2019, over 250 of our distribution substations contained either a transformer or circuit breaker that was installed more than 50 years ago. These substations with critical components beyond their expected lives serve over 500,000 of our 1.2 million customers. If we had not begun upgrading our substation fleet in 2019, over 50 additional distribution substations serving an additional 200,000 customers would have a critical component reach 50 years of age by 2023.

An example of the distribution grid approaching obsolescence is our underground system, which continues to increase in age as over 2,500 miles -over 30% of our underground system- has already exceeded its expected life, presenting an increasing risk to customer reliability and safety. Over 800 miles of the system is categorized as First Generation and Older, meaning it has already exceeded its expected 40-year life. First Generation and Older lines have more than twice the number of failures compared to a Fourth Generation, which includes cable that has not yet reached its expected life.

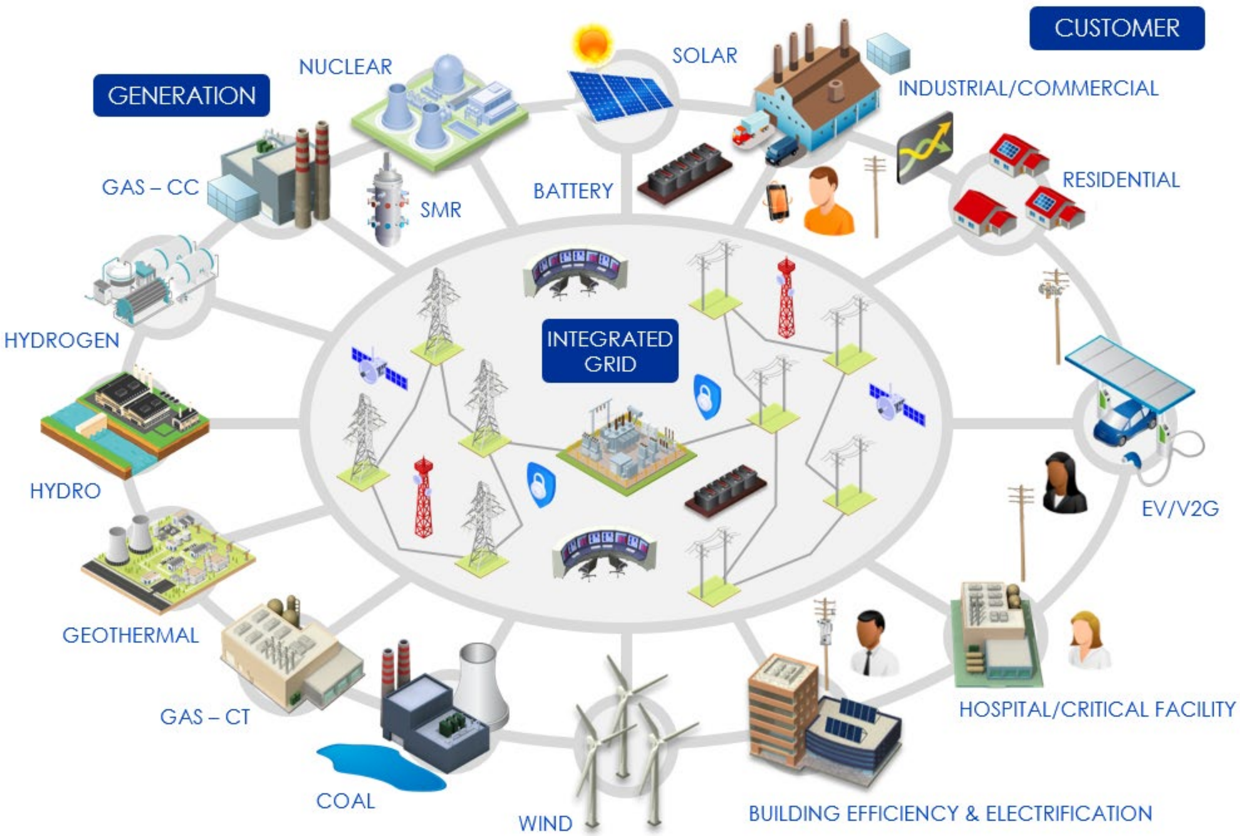
In addition, a large portion of our overhead system is over its expected life. One marker we have for the age of the overhead system is pole age. The expected life of Ameren's poles is 45 years, and our data shows that any pole over the age of 45 years old is eight times more likely to fail inspections than those that are under 30 years old. Over a third of Ameren Missouri's poles are well over the age of 45 years, meaning that approximately 1,600 miles of Ameren Missouri's distribution grid is at increased risk of failing inspections.

While the correlation of age and reliability across an asset, or set of assets, lifecycle is a simplistic representation of a much more complex interplay of factors such as loading, maintenance cycles, exposure to weather, among many other elements, the fact that there is a significant correlation shows how important it is that we properly invest in our system.

### 7.2.3 The Integrated Grid of the Future

Beyond the need to replace or upgrade aging and end-of-life components, and an increased prevalence of automation and "smart" devices, today's energy grid inherently operates much the same as it has for the past 100 years. Yet, the electric grid of tomorrow will need to be more complex. We expect that the traditional central station generation, transmission, and distribution system will evolve into the Integrated Grid, which will incorporate increasing levels of distributed energy resources and customer interfaces (e.g., connected devices and homes, electric vehicles). Such changes will work together in a coordinated, bi-directional fashion to continuously and reliably maintain the balance between resources and demand, as seen in Figure 7.2. This grid will help support customers' growing expectations, provide them greater insight into their energy usage, and better inform choices over how they use energy.

**Figure 7.2 Power Flow – Future State**




## 7.2.4 Smart Energy Plan

### *7.2.4.1 Introduction*

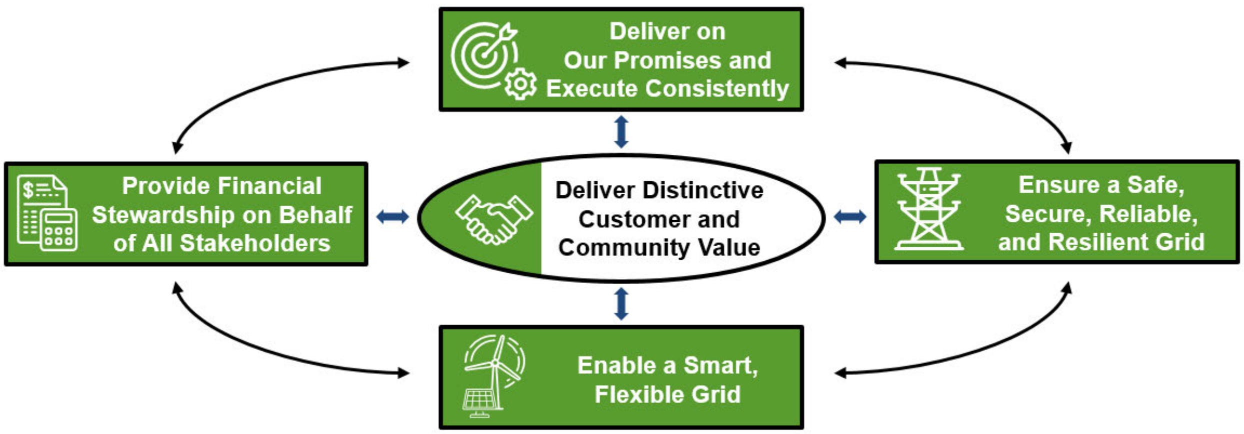
At Ameren Missouri, we are working diligently for our customers, the communities we serve, and our co-workers through Ameren Missouri's Smart Energy Plan. In 2018, the Missouri legislature, energy companies, customers, business organizations, and Missouri leaders collaborated on passing a landmark energy legislation (Missouri Senate Bill 564) that modernized Missouri's energy policies, enabling the SEP. In 2022, the Missouri legislature reiterated their support of SEP through the passage of SB 745. This bill ensured the continuance of these critical grid modernization efforts, which are vital to our customers and the communities we serve.

This forward-looking plan includes $9.9 billion of electric investments from 2023 through 2027 that will, among other things, support our investments in replacing and upgrading aged infrastructure, system hardening and resiliency efforts, and adding smart grid technologies. These investments are supporting customer reliability – they have already prevented over 30 million minutes of customer outages in 2023. As we build this grid of the future, Ameren Missouri continues working to keep rates as low as possible while making the necessary investments to build a stronger, smarter and cleaner energy system for our customers. That's why our residential rates remain 18% below the Midwest average compared to other electric utilities. The plan also accelerates the construction of smart energy infrastructure that will drive job creation and economic development across Missouri.

#### 7.2.4.2 SEP Strategic Goals

Based upon our vision of the Integrated Grid, Ameren Missouri has developed guiding principles that put customer value front and center to drive implementation of the Smart Energy Plan, as shown in Figure 7.3.

**Figure 7.3 Smart Energy Plan Guiding Principles**




These guiding principles are underpinned by a number of outcome-driven strategic goals:

- Upgrade aging and under-performing assets (e.g., substations, overhead and underground assets). As part of our plan, we are addressing the lowest performing circuits across our service territory to improve reliability for our customers.
- Automate portions of the electric distribution system by deploying smart switching devices with associated circuit upgrades and accompanying communications technologies to help significantly reduce the length of outages.
- Harden the 34 kV and 69 kV electric distribution system with a stronger, more secure energy delivery backbone, strategically using stronger poles, standoff insulators, shield wire, and wind tolerant conductors that will better withstand severe weather. Hardened circuits are designed to avoid momentary outages due to lightning strikes, as well as the possibility of extended outages from high winds and other severe weather.
- Employ smart grid technologies (e.g., relaying, monitoring, fault information, communications) as we upgrade aging and end-of-life infrastructure and install new substations to improve reliability for customers and mitigate risk.

- Improve operating flexibility, increase capacity, and enable a bi-directional flow of power from future DERs by upgrading substations and lines and adding smart switches. When severe weather or other events occur, customers can have power restored through switching to prevent or reduce extended outages, but only if lines and substations have the capacity to serve additional load. Part of this work includes the strategic conversion of some areas served by 4 kV power lines to a system standard of 12 kV. This allows for the use of standardized equipment and increased operational flexibility through the ability to add ties between circuits to allow switching to occur. Additionally, this will allow us to serve customers' future needs that continue to change with the transition to electrification.
- Continue to execute the underground revitalization program in the City of St. Louis and surrounding communities. The program significantly reduces aging and end-of-engineered-life infrastructure, some of which is over 100 years old, while increasing route diversity, thus reducing the risk of very long and widespread outages due to a single incident.
- Develop a communications network to monitor and unlock the full benefits from smart automated devices and enable analytics from connected grid devices.
- Provide Smart Meter time-of-use rates, improving customer options for managing their bills and shifting load from peak to off-peak times to benefit the grid.

### *7.2.4.3 Smart Energy Plan Highlights*

#### Smart Meter Program

The Ameren Missouri Smart Meter Program continues to upgrade all electric meters, gas modules, and the associated communication network in the Missouri service territory over approximately six years, from 2019 through 2024. This work includes:

- Installing 1.2 million Electric Advance Metering Infrastructure (AMI) meters (residential and commercial/industrial), which provide greater usage insights and capabilities for customers.
- Installing 132,000 Gas AMI modules (residential and commercial/industrial). This does not include new gas meters, only the communication module of the meters.
- Deploying a modern RF mesh network, enabling two-way communication.
- Installing an Advanced Meter Data Management System.
- Modernizing the Ameren Missouri Meter Shop to facilitate the receipt and quality testing of purchased meters.
- Creating an Ameren Missouri Network Lab.

These upgraded electric meters and gas modules will replace all of the antiquated Automated Meter Reading (AMR) meters/modules. The existing AMR meters/modules use meter reading technology that is more than 20 years old and were installed between

1995 and 2000, thus exceeding their expected life (projected to have a 15 to 20-year life). These upgrades are expected to have a number of associated benefits:

- Smart sensors, switches, self-healing equipment, work together to rapidly detect and isolate outages and more quickly restore power in the event of a service disruption.
- Smart meters enable Ameren Missouri to pinpoint outages in order to more quickly restore customers' service. Smart meter rate options (e.g., time-of-use rates) help customers manage their bills and shift load from peak to off-peak times to benefit the system.
- Improved mobile and web-based tools provide customers with greater visibility into their energy usage and greater control to manage their energy costs. Customer rates are kept affordable through a reduction in meter infrastructure operating costs by, for example, reduction in meter reading costs and enabling remote disconnect/reconnect capabilities.

From 2019 through 2022, Ameren Missouri installed 772,600 electric AMI meters, along with 54% of the RF mesh network, the meter shop, and network lab. In 2023, we plan to install another 294,000 electric AMI meters.

### Substations

Ameren Missouri has approximately 530 distribution substations and more than 100 bulk-supply substations on its system. As was previously discussed in Section 7.2.2 – The Aging Grid, there is a significant population of substations, which serve more than 40% of our customers, that are approaching end-of-life and contribute significantly to reliability issues and increasing maintenance costs.

To combat this trend, Ameren Missouri's SEP called for at least 70 new or upgraded substations in the first five years (2019 through 2023) of the program. These new and upgraded substations will improve energy service reliability through a network that is more efficient. From 2019 through 2022, we have upgraded 75 substations and are forecasted to upgrade another 36 substations in 2023, meeting our original SEP goal. Our long-term goal is to upgrade another 100 substations.

Modernized substations feature automated sensors and smart technology equipment to create a self-healing system that more rapidly detects and informs us of outages and reroutes power to restore service. They also include other "smart" technology equipment (see Section 7.2.8.3 Smart Substation Technologies).

## Distribution Automation

More than ten years ago, Ameren Missouri started to deploy distribution automation (DA) devices across the grid. This program was developed due to the significant improvement in reliability, up to 40%, when these devices were added to circuits. Ameren Missouri was able to greatly accelerate this process through the SEP and facilitate having greater portions of the system equipped with smart, automated equipment that improves remote visibility and control. Because of this, the system is able to rapidly detect outages, reroute power, and restore service. From 2019 through 2022, we have installed 1,178 DA devices and are forecasted to install 290 DA devices in 2023 out of a total of approximately 2,350 DA devices, which is considered full distribution deployment. The result of full DA deployment will be self-healing capabilities across much of the distribution system.

## Grid Resiliency

The Grid Resiliency category supports reliability by adding capacity to serve localized growing loads and to improve the flexibility and switching ability of Ameren Missouri's substations and lines. Switching power flow around an outage through an alternate pathway is the fastest way to restore customers who are impacted by a grid outage. However, the ability to switch is often impaired by infrastructure that is already at or near capacity due to load growth or design constraints. One impact of these constraints is the requirement to disable substation automatic transfer schemes during periods when loads are higher (e.g., during summer or winter peaks). There are currently 24 substations operated in this manner during the summer season. These substations are a focus of the category, prioritized by their load and number of customers served. Improvements in this category will also serve growing areas with commercial and industrial customers and areas with expanding subdivisions.

## Underground Revitalization

Our plan for Underground Revitalization is to increase reliability by upgrading aging and end-of-life infrastructure in downtown and surrounding metro St. Louis. From 2019 through 2022, we upgraded 64 miles of our underground network infrastructure and are forecasted to upgrade another 17 miles in 2023. After such investments in 2023, 76 of the total 116 miles in downtown St. Louis will be underground. Historically, our underground network has exhibited a very high level of reliability. However, as the underground infrastructure ages beyond its useful life, complications and delays can arise when performing unplanned outage repair work. New underground pathways are being built to upgrade aged, paper insulated, lead covered cable with more environmentally friendly Ethylene Propylene Rubber cable. These new pathways and cables are being installed in a route-diverse configuration to eliminate the possibility of multiple underground cable failures from a single event.

Additionally, the Underground Revitalization strategy is contributing to grid modernization by incorporating the installation of modern switching equipment to remotely manage the grid. Automated switching can reduce outages experienced by customers from hours to seconds and minimize the time required to locate and make repairs to underground assets.

#### Underground Cable

In Ameren Missouri's service territory, almost 8,000 miles of underground cable exist, with more than 30% having reached its expected life of 40 years. Our plan targets this end-of-life underground cable infrastructure. From 2019 through 2022, we upgraded 320 miles of underground cable and are forecasted to upgrade another 81 miles of underground cable in 2023. Our long-term goal is to upgrade 800 miles of underground cable.

The two major types of upgrades are direct buried primary laterals that supply subdivisions and lead feeder exit cables coming from substations. In the direct bury upgrade program, Ameren' Missouri's historic strategy has been to reactively replace sections of cables upon failure. Our current strategy is to utilize a proactive, planned approach and identify problematic primary laterals and/or entire subdivisions that require full replacement. This approach will improve efficiencies, help balance resources, and improve reliability for customers. Since primary cables are the mainstay of the subdivisions, they will become the focus versus the ties to individual houses.

#### Private LTE

Initially, our plan is to deploy private Long-Term Evolution (PLTE) transmitters to approximately 50 sites in the greater St. Louis metropolitan area to provide uniform PLTE coverage. This expansion will provide a consistent, private cellular network to operate additional smart devices and will provide better real-time system operational information. This is part of a larger effort further described in Section 7.2.8.4, Multi-Layered Network Architecture. As a part of Ameren Missouri's SEP, we aim to complete the installation 15 PLTE towers through 2023.

## 7.2.5 Initiatives

### *7.2.5.1 System Inspection*[17]

Ameren Missouri assesses the age and condition of distribution system equipment with regular inspection, testing and equipment replacement programs as described below.

[17] 20 CSR 4240-22.045(1)(A)

### Circuit and Device Inspections

Ameren Missouri inspects distribution circuits (2,400 V to 69,000 V) at least every four years in urban areas and every six years in rural areas, in compliance with Missouri PSC Rule 20 CSR 4240-23.020, to protect public and worker safety and to proactively address problems that could diminish system reliability. The program includes follow-up actions required to address noted deficiencies. Inspections include all overhead and underground hardware, equipment, and attachments, including poles. Infrared inspections are performed on overhead facilities, underground-fed transformers, and switchgear to detect any abnormalities in equipment. Wooden poles are treated every 12 years as appropriate for purposes of life extension. Inspectors may also measure impedance of the static-protected grounding system. Radio-controlled capacitors, reclosers, and sectionalizers are inspected on a four- or six-year cycle in conjunction with circuit inspections. Ameren Missouri also replaces a number of transformers each year with higher efficiency units when corrosion, oil leaks, or other visually detectable issues occur.

### Substation Asset Management

Ameren Missouri schedules substation maintenance to maximize reliability of equipment and selectively performs various diagnostic tests to obtain meaningful data to predict and prevent failures. Many tests, such as infrared scanning to detect abnormal equipment heating, can be performed with the equipment in-service. Corrective maintenance is scheduled largely on the basis of diagnostic data, with the intent of restoring equipment to full functionality. As discussed in Section 7.2.8, Advanced Distribution System Technologies, when it is no longer practical to make repairs, old equipment is replaced or upgraded with new equipment, and where practical, advanced technology that places an emphasis on system automation is installed, resulting in improved efficiency and reduction of losses.

### *7.2.5.2 System Planning*[18]

Ameren Missouri expects and plans for today's electric grid to evolve into a more integrated and complex system, one more capable of operating in the face of extreme weather and has developed a broad modernization strategy to that end. A key aspect of our SEP vision and this strategy is to increase operating efficiency and flexibility which allow for increasing levels of distributed energy resources and customer interfaces, all working together in a coordinated, bi-directional fashion. While our approach is in its early stages, we are taking steps to build the necessary tools, capabilities, competencies, and organizational structures to proactively deliver this energy future.

A significant step in this process is the coordination and centralization of key planning functions to better enable a true integrated distribution planning approach. Although Ameren Missouri has had a consolidated System Planning function for the sub-

[18] 20 CSR 4240-22.045(1)(A)

transmission system for many years, it wasn't until 2019 that the company began consolidating key elements of distribution planning and created a Low Voltage Planning Group. Additionally, a position for DER planning was added in 2022. These centralized groups are providing subject matter expertise and streamlining efforts including load analysis, engineering methods/best practices, and worst performing circuits. We also include the analysis of the impact of larger solar installations on the distribution system, hosting capacity for DER and EV, electrification, and further innovation in the distribution system.

### Annual Load Analysis and System Planning Process

Ameren Missouri records historical summer and winter peak load conditions (power, power factor, phase balance and voltage levels) at bulk and distribution substations. Distribution loads are temperature-corrected to represent 1-in-10-year maximum values using multipliers derived from statistical analyses of historic load data for several types of area load characteristics. Temperature adjustments for bulk substations are derived from historical temperature vs. loading profile curves from the distribution substations fed by the bulk substation. Engineers also enter adjustments for known or expected specific local load growth from factors including but not limited to planned residential subdivisions, apartments or condominium complexes, and commercial and industrial developments.

Engineers also calculate bulk-supply substation loads using a power flow computer model that simulates the electric power delivery system. Using temperature-corrected distribution substation loads and current equipment ratings as inputs, the software calculates bulk-supply substation loads. The substation loads are then compared to temperature-corrected values and used to evaluate what, if any, diversity factors apply at each bulk-supply substation.

After verifying the validity of the system model, engineers conduct seasonal planning studies of winter and summer peak conditions, evaluating worst case single-contingency failure scenarios for all bulk-supply substations, 34,500 V and 69,000 V circuits, distribution substations, and distribution circuits. These studies pinpoint system limitations and enable engineers to identify upgrades required to maintain adequate system capacity. The maintenance of adequate system voltage levels is included in the analyses.

Planning system upgrades to withstand single-contingency outage conditions ensures that load levels will remain within circuit capabilities for such events. Under normal conditions (the majority of the time), individual circuit elements operate at lower load levels with correspondingly lower losses.

In all the load analysis and system planning described above, the impacts of energy efficiency are included as a consideration based on the historical summer and winter peak load baselines. Historical realized energy efficiency benefits are a reliable indicator, from a system planning perspective, of what system impacts and conditions we can expect to exist from energy efficiency in the future.

### Distribution System Engineering Analyses

The Transformer Load Management (TLM) system relates customers to the distribution transformers serving them, allowing Ameren Missouri to predict transformer peak demand and apparent power from the customers' total monthly energy usages. Ameren Missouri uses this information to analyze distribution circuits and to reduce distribution losses through the more efficient loading of transformers. Additionally, customer meters are automatically read during peak load periods to confirm the transformer peak demands calculated with the TLM system.

Synergi Electric software by Det Norske Veritas – Germanischer Lloyd and PSS/E software by Siemens PTI are used to analyze distribution circuits, ensuring reliable, safe, and efficient operation of the distribution system. Synergi or PSS/E is used for: load estimation, power flow analysis, voltage flicker, phase balancing, and capacitor placement. Both software systems allow engineers to analyze existing, alternate, or proposed configurations for over/under voltages/currents, line losses, appropriate conductor sizing, and optimal capacitor placement.

Supervisory Control and Data Acquisition (SCADA) is used to remotely monitor and control the electric distribution system. Engineers use SCADA data to ensure that system models properly reflect real distribution system conditions, thereby enabling better planning of future system development.

### Capital Project Evaluation[19]

As part of SEP, Ameren Missouri routinely assesses the feasibility and cost effectiveness of potential system expansion and modernization projects. Both conventional and advanced technologies are regularly considered. Due to the age of our grid and recent trends in load growth, the majority of approved projects focus on system reliability improvement and modernization.

In 2022, Ameren Missouri developed project evaluation methodologies and frameworks to justify the six SEP categories of investments. Below is the breakdown of Ameren Missouri's frameworks and applicable evaluation criteria used in these justification methodologies:

[19] 20 CSR 4240-22.045(4)(C); 20 CSR 4240-22.045(4)(D); 20 CSR 4240-22.045(4)(D)1; 20 CSR 4240-22.045(4)(D)2; 20 CSR 4240-22.045(4)(E); 20 CSR 4240-22.045(4)(E)1

**Figure 7.4 Project Evaluation Framework**

| Criteria | Grid Resiliency | Downtown Underground | Smart Grid | System Hardening | Underground Cable | Substation Condition Based |
|---|---|---|---|---|---|---|
| Age/Asset Vintage | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Asset Condition | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Asset performance | | ✓ | | ✓ | ✓ | ✓ |
| Potential for Community Impact | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Safety | | ✓ | | | ✓ | ✓ |
| Capacity | ✓ | | | | | |
| Operating Flexibility | ✓ | | | | | |
| Circuit Topology/Grid Visibility | | | ✓ | | | |

## Electric Vehicles and Industry Trends

Our innovation is guided by the Ameren vision – leading the way to a sustainable energy future – which rests on four pillars: environmental stewardship, social impact, governance, and sustainable growth. We are driving environmental stewardship forward with efforts like the DC fast charging projects, coupled with research into large stationary batteries. This allows us to reduce the impact of DC fast chargers on our distribution circuits. We are also making a social impact through our St. Louis Vehicle Electrification Rides for Seniors (SiLVERS) program and Diversity, Equity and Inclusion Accelerator, which provides direct support to disadvantaged communities in our service territory.

Ameren Missouri is also monitoring electric vehicle growth as new loads join the system. We are currently engaging EPRI to investigate the impacts on our system for expected EV growth. The study also intends to examine and propose updated service transformer planning standards for new homes in the service territory.

## 7.2.6 System Efficiency[20]

### *7.2.6.1 Periodic System Loss Study*

Ameren Missouri evaluates the efficiency of its overall electric delivery system on a periodic basis by performing a comprehensive loss study. Losses in each portion of the system are calculated under peak load conditions using the computer software noted previously. Loss data from these evaluations are used in ongoing system planning activities, load research activities, and as supporting information for rate reviews.

### *7.2.6.2 System Upgrade and Expansion Projects*

By their nature, many types of energy delivery upgrade and expansion projects improve system efficiency by reducing load current, $I^2R$ losses, or both. Examples of such projects include:

- Constructing new circuits or rebuilding existing circuits that make use of higher operating voltages, as in the conversion of power lines from 4 kV to 12 kV or the migration toward 138 kV-fed distribution substations in specific and limited circumstances
- Constructing new circuits or rebuilding existing circuits with larger conductors
- Reconnecting single phase loads on three phase circuits to achieve balanced system phase currents
- Constructing new pad-mounted transformers with distribution automation devices to eliminate aged, rural (less than 2.5 MVA) substations
- Upgrading existing substations or strategically placing new substations to serve areas with increasing load density, using 38 kV switchgear
- Reconfiguring distribution feeders as appropriate when connecting new customers

## 7.2.7 Distributed Generation

Ameren Missouri evaluates distributed generation (DG) and its impact on the distribution system. One example is the Ameren Missouri owned and operated South St. Louis Renewable Energy Center, a Neighborhood Solar project in St. Louis. This project includes the connection of 200 kW AC solar photovoltaic generation (also referred to as Habitat for Humanity) to the local 4 kV distribution system.

Potential projects are analyzed on a case-by-case basis. At this time, Ameren Missouri is evaluating the potential installation of additional photovoltaic generating capacity at a number of locations. There are a multitude of factors that influence the evaluation of potential DG installations such as noise and/or emissions ordinances, operational complexities associated with fuel availability, equipment maintenance, and the fact that

[20] 20 CSR 4240-22.045(1)(A)

traditional system expansion projects usually provide secondary benefits like improving reliability which can offset the costs of installing DG.

Ameren Missouri generally cannot dispatch customer-owned DG at this time, so this type of resource is not included when performing load analysis and system improvement evaluations. Chapter 8 explores distributed generation as a demand-side resource.

## 7.2.8 Advanced Distribution System Technologies[21]

Ameren Missouri has developed the SEP to transform our electric grid and create a distribution infrastructure that is more secure, modern, resilient, reliable, and efficient. As part of this plan, the company has a number of previously discussed strategies to foster and disseminate proven advanced distribution system technologies broadly across our system.

### *7.2.8.1 Conventional vs. Advanced Technology Equipment*

While the basic function of power delivery systems is not changing (we still need generators, transformers, overhead and underground circuits, switches, circuit breakers, fuses, etc.), what is new is the ability to better sense system conditions, evaluate the health of system equipment, and employ either local or remote control schemes through advanced equipment via high-speed two-way digital communications technology. Some replacements are programmatic (on a set schedule), while others are implemented as equipment is replaced due to age or failure. Several types of conventional equipment and their advanced technology replacements are outlined below. This list is representative of present options, but certainly does not include every advanced technology item available today or in the future.

[21] 20 CSR 4240-22.045(1)(A); 20 CSR 4240-22.045(1)(D); 20 CSR 4240-22.070(1)(B); 20 CSR 4240-22.045(4)(B); 20 CSR 4240-22.045(4)(E)1

| Conventional Equipment | Advanced Technology Equipment |
|---|---|
| Solid Blade Manual Switch | Remote Control Switch with SCADA communication and current/voltage monitors or Electronic Recloser |
| Oil Type Recloser | Electronic Recloser with SCADA communication and current/voltage monitors and fault location capability |
| Faulted Circuit Indicator | Faulted Circuit Indicator with SCADA communication |
| Capacitor Control (Time / Temp / 1-way comm.) | Local/Remote Capacitor Control with 2-way comm. and current, voltage, kVA and status monitors |
| Underground Manual Switch | Pad-mounted Switch with SCADA communication and current/voltage monitors and fault location capability |
| Network Protector | Advanced Network Protectors with SCADA communication and current/voltage/load and equipment condition monitoring capability |
| Electromechanical Relays | Microprocessor Based Relays with SCADA communication and current/voltage/load/fault impedance/equipment condition monitoring/etc. capability |
| Transformer Bushing Tests | Online Bushing Power Factor Monitoring |
| Transformer Oil Tests | Online Transformer Oil Monitoring |
| Fuse | Trip Saver Fuse – acts as a recloser after initial fault; if fault does not clear it then operates as a fuse and isolate the fault |
| Circuit Breaker Timing Tests | Online Breaker Timing and Contact Wear Monitoring |

#### *7.2.8.2 Automated Switching Applications*

Ameren Missouri's design strategy for the sub-transmission (34.5 & 69 kV portion of our distribution system) system includes providing redundant service in a preferred-reserve fashion to distribution substations with load in excess of 10 MVA. Substations with loads below 10 MVA typically employ radial configurations with single supplies. In densely populated areas, redundant sub-transmission circuits are typically available at each substation, but redundant circuits are not always available at all substations in less populated areas. In such locations, redundant sub-transmission supplies are typically provided via automated switching devices in nearby circuits and a radial supply circuit is extended to the substation in question. Ameren Missouri focuses on minimizing the length and exposure associated with such radial supply circuits until further development achieves full redundancy at the substation.

Whether a line switch or part of a substation, Ameren Missouri employs modern, SCADA-controlled, automatic smart switching devices in order to limit the time and effort required to execute switching actions. Substation transfer schemes are designed for automatic operation, while line switches may be designed for automatic or remote-control operation, depending upon the circumstances involved. Conventional manual switches are only employed in less critical locations, where the device does not allow for automatic or remote operation. In recent years, several existing manual switches have been upgraded to remote control capability or replaced by new SCADA-controlled equipment.

As previously discussed in section 7.2.4.3 Smart Energy Plan Highlights, Ameren Missouri's strategy for automating 12 kV distribution circuits is to install SCADA-equipped smart switching devices (at least one bisecting the feeder backbone and at least one tying the downstream section to a different feeder) to limit the load dropped due to a single line contingency to roughly half the feeder's peak load. Although this is a general design objective, it can only be implemented in those cases where the existing circuit topology supports the restoration of unfaulted line sections to a different feeder. Where appropriate, Ameren Missouri is prioritizing projects based on the Worst Performing Circuit (WPC) list and Customers Experiencing Reliability above Targets (CERT) list. The first priority is the WPCs, with the second priority to add DA on CERT feeders. Within these groups, Ameren Missouri uses reliability history, number of total customers impacted, truck rolls, patrol times, and effect to existing high-impact locations to inform our decisions around these upgrades. Our long-term goal is to have one smart switch (DA device) per approximately 400 customers to provide more reliable service throughout our territory.

#### *7.2.8.3 Smart Substation Technologies*

For many years Ameren Missouri has been building substations that are considered "smart" by today's standards. As a means of ushering in the next generation of substation intelligence in the industry, Ameren Missouri has adopted Smart Substation Design Guidelines to incorporate combinations of the following features into the standard design of capital projects:

- Fault detection and location monitoring
- Switchgear circuit breaker timing and contact wear monitoring
- Circuit breaker trip coil failure monitoring
- Multi-function temperature sensing

These projects include the construction or re-build of entire substations as well as the installation or replacement of substation transformers. Additionally, going forward, mobile substation transformer and switchgear purchases will feature a combination of these types of sensors.

Industry data indicates that over the long term, the capture and trending of substation transformer diagnostic sensor data can reduce substation outage events due to unforeseen transformer failures and extend the average operating lives of these large assets. Ameren Missouri plans to continue installing sensor technology on substation transformers over time as an integral part of its capital substation projects, including those undertaken for reasons of load growth, reliability upgrade, or condition-based maintenance.

#### *7.2.8.4 Multi-Layered Network Architecture*

Currently, several isolated and overlapping networks are operating in support of AMR meters, radio-controlled line capacitors, substation SCADA and automated switching, none of which is sufficient for the long-term expansion and widespread use of intelligent end devices. We anticipate that more capacity will be required for ultimate end device populations in the tens of thousands. We also expect more speed could be required to support large file transfers from remote diagnostic sensors in substations.

In response, Ameren Missouri has developed and is deploying a multi-layered network architecture intended to support existing smart applications and enable future applications – a Wide Area Network (WAN) backbone for backhauling large amounts of field application data, Local Area Networks (LANs) for aggregating intelligent end device data (typically at substation locations), and Field Area Networks (FANs) for supporting communication with field end devices beyond and downstream from the substation.

Ameren Missouri is developing a WAN that leverages various industry-proven transport systems such as fiber, digital microwave, and common carrier leased services, and likely features a mix of private and non-shared public infrastructure of either a wired or wireless nature. Over time, WAN infrastructure additions will focus on the connection of substations and other key network entry points, the delivery of information to the control center(s), and the application of necessary security layers throughout the network architecture.

Ameren Missouri is deploying LAN technology over time at substations as their specific locations are identified as effective aggregation points for planned feeder deployments of intelligent end devices like automated line switches, capacitors, and regulators. Since these devices are being deployed on the distribution system by circuit or substation, the already owned or leased substation site becomes the preferred choice for this aggregation. Targeting these deployments at "smart" substation sites also allows for communications consolidation and maximizing the impact of LAN infrastructure investment.

In some areas of the Ameren Missouri service territory, the FAN will feature a radio frequency (RF) mesh network that is both self-organizing and self-optimizing, dynamically routing data communications amongst a diverse set of paths that wirelessly interconnect multiple end devices. In other areas, the FAN will feature a more traditional point-to-multipoint RF network or a cellular-based alternative, depending on the application and its inherent reliability and latency requirements. Ameren Missouri plans to adopt the use of intelligent end devices with open architectures as endorsed by National Institute of Science and Technology standards, regardless of the smart applications involved and the other technology choices made.

#### *7.2.8.5 Advanced Distribution Management System (ADMS)*

In 2014, Ameren Missouri implemented an Advanced Distribution Management System as a means of providing an integrated suite of software applications with which to manage the electric distribution system. ADMS is a highly integrated system of applications that provides distribution system operators a common user interface with which to monitor and control the distribution system on a daily basis. It not only replaced existing applications like outage management and switching orders, and enhanced features of Supervisory Control and Data Acquisition, but it also incorporates advanced applications such as dynamic circuit modeling, switching and restoration simulations, and a distribution system dashboard.

ADMS is foundational to future Ameren Missouri Smart Grid planning since it enables advanced applications that rely on the integration of functions formerly separate and distinct. In addition, ADMS allows for growth and scalability that is not feasible on legacy platforms and provides the flexibility to add and integrate future applications.

#### *7.2.8.6 Supervisory Control and Data Acquisition*

Ameren Missouri's strategy for substation supervisory control and data acquisition is to programmatically introduce remote load monitoring at existing substations lacking such capability for purposes of improving daily operations and facilitating the long-term planning of substation assets. Remote outage detection and supervisory control features will be introduced at existing substations lacking such capability on a strategic basis in association with other capital projects.

Ameren Missouri's 30+ years of experience in this area has shown that continuously updated load information on substation components can quickly identify unforeseen overloads, release capacity by allowing for daily operation closer to margin, and greatly enhance outage restoration activities. Remote metering also enables automatic transfer capability in smart switching applications and enables feeder level optimization via phase balancing and the operation of line capacitors. Supervisory control of switching devices further enhances operations by allowing for real-time outage notification and immediate intervention by dispatchers in restoration scenarios.

There are approximately 160 Ameren Missouri distribution substations without outage detection and supervisory control capability. Ameren Missouri's plan is to convert these substations opportunistically over time as other capital projects are undertaken to replace their switching devices. Ameren Missouri is also funding the programmatic addition of metering and SCADA capabilities at some of these substations, which are not scheduled for other upgrade projects in the foreseeable future.

#### *7.2.8.7 Capacitor Control*

Smart line capacitor operation has helped Ameren Missouri maintain a consistent 98% distribution system power factor over the last twenty years. However, the capacitor control technology available today allows for feeder level efficiencies and degrees of optimization that were never before possible. The use of "smart" capacitor controls not only helps achieve these levels of efficiency and optimization, but also effectively controls customer end use voltages, and reliably supports the reactive requirements of the transmission system. Ameren Missouri leverages the ADMS system capabilities to integrate substation load monitoring with "smart" line capacitor operation in order to achieve these goals.

Ameren Missouri’s first step as part of this automation strategy is the deployment of the next generation of "smart capacitor" technology on the distribution and sub-transmission systems. Ameren Missouri will leverage the need to replace the existing 25-year old line capacitor control system in operation today in the St. Louis metro area for this deployment. To this end, 2,300 capacitor controls will be upgraded over the next 5-10 years.

Additionally, Ameren Missouri will be installing "smart" capacitors in place of the remaining 425 non-fixed units in the service territory. This deployment will take place over time by circuit, substation, or group of adjacent substations, coincident with the deployment of automated switches in order to maximize the benefits associated with the communications investment.

#### *7.2.8.8 Voltage Optimization*[22]

Ameren Missouri has engaged a third party, EPRI (Electric Power Research Institute), to evaluate the impacts of Ameren Missouri deploying Voltage Optimization through Conservation Voltage Reduction (CVR) across the distribution grid. CVR is the process of operating near the lower voltage threshold at the customer delivery point and has previously been utilized by utilities as a means to reduce load at peak times and potentially reduce customer energy, if system attributes are favorable. To estimate the impacts potential of CVR for Ameren Missouri, EPRI is evaluating the effectiveness of CVR on the Ameren Missouri distribution grid and on the loads that make up AMO customers including specific devices, (e.g., EV’s and appliances), and what the anticipated mix of loads will be over the next twenty years. The evaluation is still on-going and we anticipate that EPRI will complete its study and issue its report later this year.

[22] File No. EO-2023-0099 1.D

## 7.3 Compliance References